(54) Title: SYSTEM AND METHOD FOR DIMENSIONING A CDMA NETWORK

(57) Abstract: The present invention relates to a method for dimensioning a network based on code division multiple access techniques or CDMA for input parameters representing coverage requirements and/or capacity requirements and/or quality requirements able to provide at least a value of maximum sustainable load per cell (η_{MAX}) given a plurality of services provided, comprising the steps of: determining a load factor per cell (η_{UL}, η_{DL}) based on input parameters; characterised by the steps of: verifying whether the determined load factor (η_{UL}, η_{DL}) corresponds to the maximum sustainable load (η_{MAX}) of a base terminal station and, if the determined load factor (η_{UL}, η_{DL}) exceeds the maximum sustainable load factor (η_{MAX}); negotiating at the radio resource management (RRM) level at least one of the services provided in said network in such a way that the determined load factor (η_{UL}, η_{DL}) becomes less than or equal to the maximum sustainable load (η_{MAX}) or is optimised taking into account the characteristics of the network.
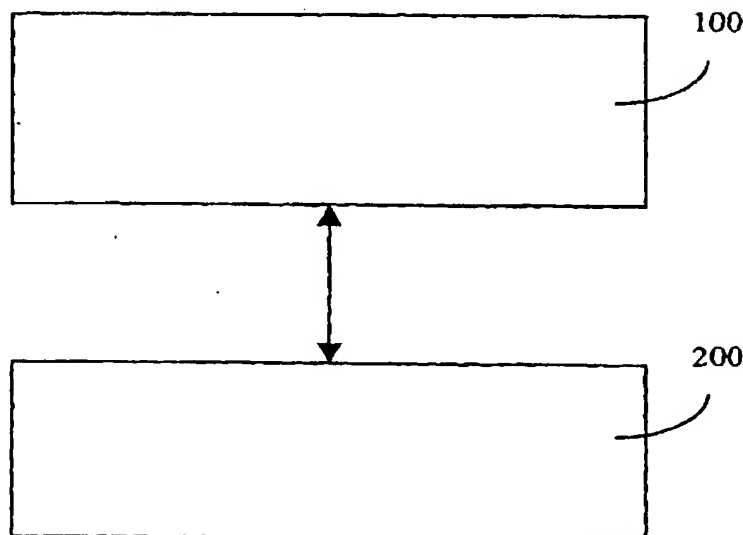
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TITLE

"System and Method for Dimensioning a CDMA Network"

TECHNICAL FIELD

The present invention relates to a system and method

5 for the dimensioning or general (analytical) planning of
a CDMA (Code Division Multiple Access) network.

In particular, the present invention relates to a system
and method for the analytical planing of a network for
third generation UMTS (Universal Mobile

10 Telecommunications System) mobile apparatuses which uses,
as is well known, a radio interface based on the Code
Division Multiple Access technique or CDMA.

BACKGROUND ART

The overall dimensioning (dimensioning) of a CDMA

15 network consists, as is well known, of determining an
estimate of the number and configuration of apparatuses
constituting the mobile network able to meet determined
requirements.

In particular, analytical planning allows, starting

20 from planning requirements such as:

- Coverage Requirements:

    Planning area to be covered;

    Geo-morphologic information about the planning area;

    Propagation conditions;

25 - Capacity requirements:

    Available Frequency Spectrum;

    Traffic Forecast per user;

    Traffic Density over the area;

- Quality Requirements:

30   Coverage Probability;

    Block Probability;

    User Throughput to be guaranteed;

the calculation with a certain degree of confidence, of elements constituting the network, such as:

- Number of Base terminal stations (BTS) or sites and configuration thereof;

5 - Equipment of the Base terminal stations in terms of:

- maximum power required and average power per traffic channel;

- required base band processing capacity;

- Load per cell for geo-morphologically homogeneous area;

10 - Percentage of use of the code tree;

- Number of carriers used.

In the case of UMTS systems, which base their operation on a WCDMA (Wide CDMA) radio interface characterised, as is well known, by the "Soft Capacity"

15 property, the prior art, for instance as reported in the book by H. Holma, A. Toskala, with the title "Radio Network Planning" on *WCDMA for UMTS*, Wiley & Sons Ltd. June 2000 recommends proceeding with the overall planning on the basis of the assumption that:

20 - dimensioning in terms of coverage (ability of the terminal to communicate) must be verified by analysing the network in regard to the radio link from the mobile terminal to the Base terminal station (uplink); and

- dimensioning in terms of capacity (the ability of the

25 network to provide services to the mobile terminal) must be verified by analysing the network in regard to the radio link from the Base terminal station to the mobile terminal (downlink).

In other words, a first limitation of the prior art

30 consists of its assumption that the effects of the uplink and of the downlink paths are distinct and that therefore

they can be evaluated in separate, though sequential, fashion.

Based on experience, it seems that such an assumption is not adequate and that a correct dimensioning of the

5 network must be conducted intersecting or combining the analysis of the uplink path with that of the downlink path.

A second limitation of the prior art relating to the dimensioning of the network by path, for instance for the

10 uplink path, consists of the fact that it does not take into account that some services are negotiable, in particular thanks to the intrinsic characteristics of CDMA networks.

Both the first and the second limitation,

15 individually or jointly, entail, in general, that analytical planning in accordance with the prior art is particularly prone to yield imprecise results, even in the order of 20-30% with respect to what can be obtained with more accurate methods.

20 **DISCLOSURE OF THE INVENTION**

An aim of the present invention is to describe a new method for the general planning of a CDMA network.

An aim of the present invention is also a system able to implement the method according to the invention and a

25 computer product which can be loaded into the memory of an electronic computer to carry out the method according to the invention.

The aim is achieved by the system and method for dimensioning a CDMA network as claimed.

30 According to a characteristic of the present invention, in dimensioning the network the method takes

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into account, for each type of path, the fact that each service can be negotiated dynamically.

According to another characteristic of the present invention, given the joint dimensioning, for the uplink
5 and downlink path, verification steps are provided that are able to request or to review the input parameters or to negotiate the services dynamically.

Naturally, the invention also relates to the computer product able to be loaded directly into the internal
10 memory of an electronic computer to carry out, when the product is executed on an electronic computer, the method according to the invention.

BRIEF DESCRIPTION OF THE DRAWINGS

This and other characteristics of the present
15 invention shall become readily clear from the following description of a preferred embodiment, provided by way of non limiting example with the aid of the accompanying drawings, in which:

Fig.1 shows a system for the general planning
20 (dimensioning) of a network for mobile apparatuses;

Fig.2 shows a general block diagram of the method according to the invention; and

Fig.3A, Fig.3B, Fig.3C and Fig.3D together show a single flow chart describing the method according to the
25 invention and related to the dimensioning of a radio network according to the invention.

DESCRIPTION OF A PREFERRED EMBODIMENT

With reference to Fig. 1, a system for the general or analytical planning (known as "dimensioning") of a mobile
30 telecommunications network comprises, for instance, a known computerised work station (Work Station) 50 having a processing sub-system (base module) 51, a display

device (display) 52, a keyboard 55 and a pointing device (mouse) 56.

The Work Station 50, for example the model J5000 by Hewlett-Packard, with a 700 MHz CPUT, 128 Mbytes RAM, an

5 18 Gbyte hard disk drive and a Windows operating system, is able to process groups of programs, or modules, stored, for instance, in the RAM, and to visualise the results on the display 52.

In the described configuration, the system is able to

10 allow, for instance, the dimensioning of a network for mobile equipment or terminals on the basis of computerised modules stored in the memory of the Work Station 50 and able to implement the method according to the invention as described below.

15 The method for the dimensioning of a mobile radio network based, for instance, on a WCDMA (Wide-band CDMA) radio interface comprises a plurality of steps that can be grouped in to logic blocks (Fig.2).

A first block (100) for preparing data for

20 dimensioning the network.

A second block (200) for dimensioning the network considering, as shall be described in detail hereafter, the radio path from mobile to Base terminal station (uplink path) and/or the radio path from Base terminal

25 station to mobile (downlink path).

In particular, in the second block 200, planning is conducted both by means of specific dimensioning steps for the uplink path and specific dimensioning steps for the downlink path, and through multiple interactions or

30 feedback between the steps relating to the dimensioning of the uplink and of the downlink path.

Moreover, in the specific steps for dimensioning the uplink path, in a manner deemed to be novel, account is taken both of coverage and of traffic aspects and, for the downlink path, account is taken both of the limited

5 number of orthogonal codes, typical for instance of UMTS networks, and of the limits of power per channel and total power of Base Terminal Stations (or BTS).

The method according to the invention allows to improve dimensioning both in regard to each path, considered

10 individually, and for the two paths, considered jointly, as shall be made readily apparent in the description that follows.

In the first block 100 are therefore provided all input parameters necessary for the dimensioning of the

15 network.

Said parameters, of a known type, correspond to those generally used by the prior art to conduct the analytical planning of a mobile network and can be considered as starting specifications or planning requirements that

20 must be met by the dimensioning.

In particular, said parameters comprise, for instance, as previously stated in the description:

- Coverage requirements or parameters, such as:

    o dimension in Km^2 of the planning area;

25   o percentages of the planning area distinguished by type of area, for instance dense urban, urban, suburban, rural.

  - Capacity requirements or parameters, such as:

    o initial number of carriers;

30   o number of usable carriers;

    o maximum load sustainable per cell or η_{MAX};

o maximum percentage of use in terms of power of the BTS stations to assure their correct operation;

o maximum power per traffic channel associated to each service on the downlink path;

5   o expected percentage of soft handover connections;

o number and type of services to be provided in the planning area under consideration. Each type of service (service) taken into consideration can be provided, as is well known, by means of appropriate

10   radio channel (Radio Access Bearer - RAB) whereon the service is to be mapped distinguishing among RABs of the following types:

- CS (Circuit Switched): Voice AMR (Adaptive Multi Rate);

15   - CS (Circuit Switched): for instance video-telephony;

- PS (Packet Switched): for instance Web Browsing.

The configurations of the parameters that define the

20   RABs (radio bearers) belonging to the three aforementioned families are set out, for example, in the specification document 3GPPTS 34.108, published by the Consortium 3GPP.

- Quality Requirements or Parameters.

25   - Configuration Requirements or Parameters relating to possible strategies for the configuration or development of the radio network, such as:

o Minimisation of the number of carriers used;

o Minimisation of the number of sites used.

30 The latter parameters can, as will be readily apparent to a person versed in the art, influence the operations or functions carried out by the block 200, albeit without

modifying the characteristics of the method according the invention.

Figs.3A, 3B, 3C and 3D show in greater detail the operations or steps carried out in the second block 200.

5   In a first step (Step U1), the value of η_{max} is attributed, which is an input data time, to a reference variable called η_{start} and used, in accordance with the method described herein, to verify whether the dimensioning meets the starting specifications, as shall
10 be described in detail hereafter.

In a second step (Step U2), the so-called "link budget" is calculated, as described in detail hereafter and, through it, the cell radius.

For instance, the calculation of the link budget and of
15 the consequent cell radius is performed with reference to the uplink path, in four sub-steps:

I) Calculation of the EIRP (Equivalent Isotropic Radiated Power) $EIRP_{Tx}$ of the terminal, using the known formula:

20   $$EIRP_{Tx} = P_{tx} + G_{tx} - L_{tx} \qquad \text{[dBm]}$$

where:

P_{tx} is an input data item and corresponds to the maximum power of the mobile terminal;

G_{tx} is an input data item of the mobile terminal and
25   corresponds to antenna gain in transmission, defined as the maximum gain of the antenna at the transmitter in the horizontal plane relative to an isotropic radiator;

L_{tx} is an input data item of the mobile terminal and
30   represents the connection losses of the transmitter;

L_{tx} , in particular, takes into account all losses due

to the components positioned between the output of the transmitter and the input of the antenna.

II) Calculation of the so-called sensitivity of the base terminal station receiver (S_{rx}). In particular, S_{rx} is the

5   power level of the minimum signal necessary at the input of the BTS receiver to meet requirements in terms of E_b/N_0:

$$S_{rx} = \frac{E_b}{N_0} + R_{dB} + S_n + F + M_{imp} \quad \text{[dBm]}$$

where:

10   R_{dB} is the bit rate of the service expressed in dB;

E_b/N_0 is the ratio between the energy per bit of information and the spectral density of thermal noise + interference. The values of E_b/N_0 used when calculating the link budget in uplink are determined,

15   in known fashion, by means of simulators of radio reception and transmission chains, also known;

S_n is the spectral density of thermal noise. $S_n = k \cdot T_0$ with $k = 1.38 \cdot 10^{-23} J/K$ Boltzmann constant and $T_0 = 290K$;

F is the noise figure of the BTS receiver;

20   M_{imp} is the so-called implementation margin; said parameter M_{imp} takes into account any deviations from the ideal of the BTS receiver and is linked to factors that depend on the construction of the BTS itself.

III) Calculation of total path attenuation or "path loss"

25   (A);

for each service said value (A) represents the maximum sustainable "path loss", i.e. the maximum loss that allows to obtain, starting from the maximum power of the

mobile, assumed to be at the cell edge, the performance required from the BTS receiver:

$$A = EIRP_{Tx} - S_{rx} + G_{rx} - L_{rx} - M_{int} - M_{PC} + G_{macro} - L_{ab} - M_{sh} - M_{PL}$$

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where:

G_{rx} is an input data item and it represents the reception antenna gain of the BTS, defined as the maximum antenna gain at the receiver in the horizontal plane

10   with respect to an isotropic radiator;

L_{rx} is an input data item and it represents the connection losses of the BTS receiver. L_{rx} takes into account all losses due to the components positioned between the output of the antenna and the input of the

15   BTS receiver;

M_{int} is only initially an input data item that represents the interference margin. In CDMA based cellular systems, the coverage provided by a base station depends on the volume of traffic to be handled: the

20   greater the traffic, the lesser the coverage provided by the cell. To take into account the influence of the load on the calculation of the coverage, said interference margin is introduced, which, as shall be seen and in accordance with the present embodiment, is

25   linked to the load factor η_{UL} of the cell through the formula $M_{int} = -10\log_{10}(1 - \eta_{UL})$ and is updated in iterative way according to the dimensioning congruence tests;

M_{PC} is an input data item and it represents the power control margin; said margin is inserted in the link

30   budget computation to allow a terminal located on the edge of the cell to increase transmission power, to

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compensate for the variations of the received signal due to fast fading. For this reason sometimes said margin is also called "fast fading margin";

5 G_{macro} is an input data item and it represents macro diversity gain; as is well known, in CDMA based cellular systems the terminal can be simultaneously connected to two base terminal stations (the so-called soft handover condition). This condition is also called macro diversity. Thanks to said peculiar

10 condition, it is possible to lower the requirements on the E_b/N_0 ratio needed for the individual connection. The macro diversity gain G_{macro} takes into account the gain which the macro diversity allows to obtain against shadowing;

15 L_{ab} is an input data item and it represents the so-called antenna/body loss. In particular, the term L_{ab} takes into account the fact that part of the signal is absorbed by the human body. In the case of high bit rate data services, said parameter is assumed to be 0

20 dB, because it is supposed that the mobile terminal is positioned at a sufficient distance from the body to consider interaction to be nil;

M_{sh} is an input data item and it represents the so-called shadowing margin. The term M_{sh} takes into account the

25 fluctuations of the received signal due to the so-called "shadowing", and it is linked, as is well known, to an additional parameter called coverage probability, which can be defined as a function of the probability of an out of service condition, also

30 called "outage", taken as the probability that the signal variation due to shadowing exceeds the

difference between maximum transmission power and the level of signal required in reception. Since the fluctuations due to shadowing have a log-normal distribution, to low outage probabilities (high

5   coverage probabilities) correspond high shadowing margins. For instance, if a log normal distribution with a standard deviation of 8 dB is considered, to a 10% probability of outage corresponds a shadowing margin of 10.3 dB;

10 M_{PL} is an input data item and it represents the so-called margin of penetration. The term M_{PL} takes into account the losses due to the presence of obstacles, typically buildings, between the transmitter and the receiver.

15 IV) Calculation of the radius of each cell (R_{COP}) belonging to geo-morphologically homogeneous areas: after obtaining the value of attenuation A [dB], the cell radius R_{COP} [km] is calculated in known fashion with a path-loss formula that depends on the environment under

20 consideration.

For instance, in the case of multi-service scenarios, typical of third generation systems, such as the UMTS system as defined in the 3GPP standard (Third Generation Partnership Project), the calculation of the radius R_{COP}

25 is achieved by repeating the four sub-steps for each service and selecting the smallest amongst the radii thus obtained.

In a third step (Step U3), from the cell radius, dividing the planning area considered by the area

30 subtended by each cell it is possible to obtain the total

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number of cells and the traffic offered to each cell (Step U4).

In an additional step (Step U5A or U5B) one obtains, as a function of the type of service, for instance

5   circuit switched (CS) or packet switched (PS), the number of channels to be allocated on the uplink path. This calculation is carried out with the following mutually alternative steps:

     5A] Erlang B Formula, in particular for CS (Circuit

10   Switched) services;

     5B] Simplified wait models, in particular for PS (Packet Switched) services.

In two successive steps (Step U6 e U7) the total load factor per cell of the uplink path (η_{UL}) is calculated;

15   in particular, the following formula is used:

$$\eta_{UL} = (1+i) \cdot \sum_{j=1}^{N_s} \frac{N_j}{1 + \dfrac{W}{(E_b/N_0)_j \cdot R_j \cdot \upsilon_j}}$$

in which the following parameters are known, i.e.:

i is the ratio between inter-cell interference and intra-

20   cell interference;

N_S is the number of services offered in the cell;

N_j is the number of users employing the jth service;

W is the chip rate;

R_j is the bit rate associated to the jth service;

25   υ_j is the *activity factor* of the jth service;

and in which the following parameter is used in a manner considered novel:

     $(E_b/N_0)_j$ is the requirement, in terms of the ratio (useful signal power) / (total interference density),

30   for the jth service.

The hypothesis that is generally adopted in the prior art, for the downlink path as well, is the presence of an ideal power control procedure, such as to guarantee to the receiver the desired E_b/N_0 ratio for each user; the value of the E_b/N_0 ratio is obtained, in this hypothesis, from the results of the physical layer simulations.

One of the elements deemed distinctive of the present invention is that of considering the effect of a real power control procedure, i.e. one that is affected by delays, errors etc.

In order to consider this effect, taking into account that due to the non ideal conditions of the power control procedure the values of E_b/N_0 measured at the receiver follow a normal or Gaussian distribution in decibels, and that to said distribution corresponds a log-normal distribution in linear, when the average value of E_b/N_0 appears, the following expression was used:

$$E[E_b / N_0] = e^{\beta m_c} \cdot e^{(\beta \sigma_c)^2 / 2}$$

where:

m_c is the average value of the E_b/N_0 ratio expressed in decibel;

σ_c is the variance of the E_b/N_0 ratio expressed in decibel;

$\beta = \ln(10)/10$.

This expression, deemed to be novel for the scope of the invention, allows to take into account power control procedures in real fashion, in particular when evaluating the per service and total load factor η_{UL}. Thanks to the fact that power control is taken into

account in real fashion, it is possible to take into account, in the dimensioning of the non ideal condition of the power control which is translated, for instance for equal planning scenarios, into an
5   increase of the number of BTS required and of their equipment in terms, for example, of power amplifiers.

Given the calculation of the load factor η_{UL}, according to the present embodiment, the following step (Step U8) consists of verifying whether said value of η_{UL}
10 corresponds to the initially set values (η_{START}) to carry out the dimensioning operation.

In particular, if the load factor η_{UL} thus determined coincides with η_{start} the method according to the invention provides, in a possible embodiment, for the
15 start of a set of steps for the dimensioning of the downlink path starting from Step D1.

This embodiment also seems novel with respect to the prior art.

If, instead, η_{UL} is smaller than η_{start} then the steps
20 U2-U7 are repeated assigning a smaller value to η_{start} (Step U15), until equality is verified (Step U8, outcome $\eta_{UL} = \eta_{start}$) in order to proceed, subsequently, to Step D1 as indicated above.

If η_{UL} is greater than η_{start} the method, according to
25 an additional peculiar characteristic of the present invention, verifies whether the RAB can be renegotiated (Step U9) and, if it is, it proceeds to "*renegotiate*" at least one of the services or a type of service (Step U14).
30 This methodology is possible, as will be readily apparent to a person versed in the art, because CDMA networks, for

instance UMTS networks are of the multi-service type, i.e. networks in which a plurality of different services is provided.

In the case of RAB of the PS (*Packet Switched*) type,
5 according to the present embodiment, a maximum Bit Rate and a minimum Bit Rate are set, compatible with the characteristics of the quality of the service to be negotiated.

Said bit rate may vary dynamically according to the
10 contingent conditions of operation of the network, for instance the radio network (e.g. variation of the system load, variation of the radio interface load).

The dynamic variations of the bit rate of each renegotiable service are managed, as is well known, at
15 the RRM level (Radio Resources Management), by means of functionalities, for instance, of the "*packet scheduling*" and "*congestion control*" type.

The method according to the invention takes into account, at the dimensioning level, of the impact that "*packet
20 scheduling*" and "*congestion control*" functionalities have on the network.

In particular, the "*packet scheduling*" functionality is simulated by varying the bit rate between maximum and minimum values as indicated when, based on the
25 "*congestion control*" functionality, the situation in which η_{UL} exceeds η_{start} is identified (Step U8, $\eta_{UL} > \eta_{start}$).

Moreover, by means of an additional RRM level functionality, called "*admission control*" in the
30 specifications, the method according to the invention provides for blocking parameters able to block the

traffic of each cell both on the uplink and on the downlink path.

In the case of voice CS RAB, for instance in the case of UMTS networks, the method according to the invention
5 provides for the so-called AMR (Adaptive Multi Rate)coding whereby the service is *renegotiated* simulating voice coding at different bit rates, for instance between 4.75 Kbps and 12.2 Kbps.

According to said coding, under particular operating
10 conditions of the radio network, for instance with high load or in poor propagation conditions, the voice service is mapped on a RAB-voice-AMR with lower bit rate that requires less of an impact from the point of view of the radio interface.

15 The method according to the present invention takes into account the impact of the AMR functionality on the network.

Therefore, according to the present embodiment, the method provides for *renegotiating* individual services or
20 individual types of service, for instance by changing the bit rate of a service, for example decreasing and increasing the required value of E_b/N_0.

Thanks to this approach, once the parameters that define the RAB on which the service is provided are modified,
25 the method allows to start from the initial step U1 in order to recalculate η_{UL}.

As shall be seen hereafter, the possibility of renegotiating the bearer of a service is also used to dimension the downlink path.

30 If instead it is not possible to renegotiate the radio bearer of any allocated service (Step U9, negative outcome), depending on the dimensioning criterion

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selected in the first block 100 of definition of the parameters for the analytical planning, if possible, the number of allocated carriers is, for example, increased, equally distributing the traffic offered for each carrier

5 (Step U11), or, alternatively, the cell radius is reduced (Step U12) and the steps U3-U7 are repeated in such a way as to vary η_{UL} until reaching the equality $\eta_{UL}=\eta_{start}$ (Step U8).

As will be readily apparent to a person versed in the

10 art, the first choice corresponds to the strategy of minimising the number of sites used, whilst the second one corresponds to the strategy of minimising the carriers used.

Once the equality $\eta_{UL}=\eta_{start}$ is determined, the

15 dimensioning of the downlink path is accomplished, in a possible embodiment.

The dimensioning of the downlink path has two objectives:

- to test whether the downlink codes tree is able to host

20 all the channels of the services required; in this way, in a manner deemed novel with respect to the prior art, an additional RRM functionality, called *"code management"* is taken into account;

- to test whether limits on transmission power are

25 obeyed, both for the individual service and for total power transmitted by the BTS (*"power management"* verification); the verification of the BTS power, which generally has a considerable impact on dimensioning, is deemed novel with respect to the prior art. This

30 verification allows to take into account the *"admission control"* RRM functionality for the downlink path.

Since these are test operations, the method provides, on each occasion when the outcome of the test is unsatisfactory, for repeating the steps for calculating the uplink path, as will be described in detail

5 hereafter.

Starting from the number of cells obtained from the dimensioning for the uplink path, in the downlink path the following parameters are computed:

- in a first Step D1, the traffic offered per cell

10 belonging to a geo-morphologically homogeneous area, dividing input traffic for each service by the number of cells obtained from the dimensioning of the uplink path;

- in a second Step D2A or D2B, the number of channels that must be allocated, also taking into account the

15 percentage of channels in soft handover; this calculation is performed, alternatively, using:

- the Erlang B formula for CS services (Step D2A);

- simplified wait models for PS services (Step D2B);

- in a further Step D3, from the number of channels

20 obtained it is possible to calculate the occupation on the code tree for each cell; in particular, it is possible to verify whether the codes relating to the requested services can be hosted on the code tree associated to each BTS.

25 This verification entails a series of alternatives.

If it is not possible to host all codes provided in downlink (Step D3, negative outcome) and if at least one service can be renegotiated (Step D4, positive outcome), the method returns to Step U14 so that a different RAB is

30 renegotiated for that service.

In this way the *"packet scheduling"* and *"congestion control"* functionality is taken into account on the downlink path.

If there is no renegotiable service (Step D4, negative outcome), then two alternatives are possible, depending on the choices made in the block 100 of initial choices for the uplink and downlink path in regard to possible network development strategies:

- Reducing the radius of the cell until obtaining a number of downlink channels that can be hosted by a single code tree (Step D5 followed by verification Step 3 with positive outcome);

- Allocating, if available, an additional carrier (Step D6). In this case the traffic is subdivided between the carriers and the method starts back from Step U1 to recalculate η_{UL}.

If the first possibility is chosen (Step D5 and Step D3, positive outcome), or if the code occupation test had a positive outcome (Step D3, positive outcome), the load factor is calculated for each service for each individual cell on the downlink path η_{DL}, based on the following known formula (Steps D8A and D8B):

$$\eta_{DL} = \sum_{i=1}^{I} \frac{(E_b/N_0)_i \cdot R_i \cdot \upsilon_i}{W} \cdot [(1-\alpha_i)+i_i]$$

where:

I is the number of users in the cell;

i_i is the ratio between the inter-cell interference and the intra-cell interference received by the ith terminal. In the algorithm, an average value for all users is employed for this parameter;

W is the chip rate;

R_i is the bit rate associated with the ith terminal;

v_i is the *activity factor* of the ith terminal;

α_i is the orthogonality factor of the ith terminal which depends on the conditions of propagation ($\alpha_i=1$ in case

5   of perfect orthogonality between the signals in downlink). In the algorithm, an average value for all users is employed for this parameter;

$(E_b/N_0)_i$ is the requirements, in terms of useful signal power/total interference density ratio, for the ith

10   terminal.

After determining the values of η_{DL} it is possible to use the following known formula to calculate the transmission power for individual services and total transmission power (Steps D9A and D9B) using the

15 following formula:

$$P = \frac{P_N \sum_{i=1}^{I} \frac{(E_b/N_0)_i \cdot R_i \cdot v_i}{W} \cdot L_{m,i}}{1-\eta_{DL}}$$

where:

P_N is thermal noise power;

20 $L_{m,i}$ is the attenuation undergone by the signal in the downlink path connecting the base station to the terminal.

After calculating the power, the method according to the present invention proceeds to compare maximum power

25 sustainable per traffic channel for a service (Power Management test) with the maximum power calculated for the same service (Step D10A);

If the maximum calculated power per channel of at least one service exceeds maximum power (Step D10A,

30 positive outcome) and the service can be renegotiated

(Step D10B, positive outcome) the method returns to step
U14 and the RAB is renegotiated.

The effect of renegotiation is dual: increase in $(E_b/N_0)_i$
and decrease in bit rate R_i. The preponderant effect is

5   the latter, which entails the decrease of the power
required in transmission and consequent variation of η_{UL}.

If it is not possible to renegotiate a different RAB
(Step D10B, negative outcome), according to the present
method it is possible, taking into account the

10   dimensioning criteria chosen in the first block 100 and
until the limit on power is obeyed, to complete the
dimensioning process, in alternative fashion:

      - by increasing, if possible, the number of carriers
      used (Step D6) and starting anew from Step U1;

15   - by decreasing cell radius (Step D18) and recycling
      on Step D10A;

      - by increasing BTS power until the power limit is
      obeyed.

If no service exceeds the power limits (Step D10A,

20   negative outcome), in accordance with the present
embodiment a last test on total transmitted power is
conducted (Step D11).

If total power P determined is lower than the maximum
power available, the method is completed and the

25   determined values correspond to the dimensioning of the
network (Step D11, positive outcome).

In the opposite case (Step D11, negative outcome) and
if the services are renegotiable (Step D12, positive
outcome) the RAB are renegotiated for the services that

30   are still renegotiable (Step U14) and the calculation
process is repeated starting from Step U1.

If there are no renegotiable services, taking into account the dimensioning criterion selected in the first block 100 and until the limit on power is obeyed, ending the dimensioning process in alternative fashion through
5 the following choices:

- by increasing, if possible, the number of carriers (Step D6) and starting again the calculation process from Step U1;

- by decreasing cell radius until the limit on total
10 maximum transmission power is obeyed (Step D18) and starting again from Step U3;.

- by increasing the power of the BTS until the power limit is obeyed.

The method described herein, and the corresponding
15 system configured to implement the method, therefore allow, in a manner deemed innovative, both to:

- dimension, in joint fashion, the uplink and the downlink path for a determined territory; and to

- negotiate in dynamic fashion the services, both for
20 the uplink and for the downlink path, taking into account RRM functionalities such as:

- Power control;

- Packet Scheduling;

- Congestion control;
25 - Admission control;

- AMR voice coding;

- Code management; and

- Power management.

Thanks to these characteristics, the method according
30 to the present invention allows to optimise the values of maximum sustainable load per cell and, hence, to achieve

a greater accuracy in the analytical planning of the number of sites, number of BTS and associated equipment.

In particular, the results verified experimentally differ from those achievable with the prior art by
5 percentages in the order of 20-30 %.

Obvious modifications or variations can be made to the description provided above, in dimensions, shapes, materials, components, circuit elements, connections and contacts, as well as in the details of the circuitry and
10 of the construction illustrated herein and in the operating method without thereby departing from the spirit of the invention as set out in the claims that follows.

15

CLAIMS

1. Method for dimensioning a network based on Code Division Multiple Access techniques or CDMA for input parameters that are representative of coverage

5 requirements and/or capacity requirements and/or quality requirements able to provide at least a value of maximum sustainable load per cell (η_{MAX}) given a plurality of services provided, comprising the steps of:

- determining a load factor per cell (η_{UL}, η_{DL}) on the

10 basis of the input parameters;

characterised by the steps of:

- verifying whether the determined load factor (η_{UL}, η_{DL}) corresponds to the maximum load sustainable (η_{MAX}) by a base terminal station or BTS and, if the determined load

15 factor (η_{UL}, η_{DL}) exceeds the maximum sustainable load (η_{MAX});

- negotiating at the Radio Resource Management (RRM) level at least one of the services provided in said network in such a way that the determined load factor

20 (η_{UL}, η_{DL}) becomes smaller than or equal to the maximum sustainable load (η_{MAX}) or is optimised taking into account the characteristics of the network.

2. Method as claimed in claim 1, characterised in that the load factor is determined taking into account real

25 "power control" procedures, by attributing to the ratio between useful signal power and total interference density of the BTS a normal or Gaussian distribution in decibels.

3. Method as claimed in claim 1 or 2, characterised in

30 that the step of determining the load factor is carried out for the uplink radio path.

4. Method as claimed in claim 3, characterised in that the step of negotiating at least one of the services provided comprises the step of negotiating one among the functionalities of

5 - packet scheduling;

- congestion control; and

- admission control.

5. Method as claimed in claims 1 or 2, characterised in that the step of determining the load factor is carried

10 out for the downlink radio path

6. Method as claimed in claim 5, characterised in that the step of negotiating at least one of the services provided comprises the step of negotiating one among the functionalities of

15 - code management;

- power management;

- packet scheduling;

- congestion control; and

- admission control.

20 7. Method for dimensioning a network based on Code Division Multiple Access techniques or CDMA for input parameters that are representative of coverage requirements and/or capacity requirements and/or quality requirements able to provide at least a value of maximum

25 sustainable load per cell (η_{MAX}) and a maximum number of radio channels associated with corresponding codes provided for a plurality of services provided, comprising the steps of:

- determining by means of "link budget" a load factor per

30 cell for the uplink radio path (η_{UL});

and characterised by the steps of:

- verifying whether the determined load factor (η_{UL}) corresponds to the maximum. load sustainable (η_{MAX}) by a base terminal station or BTS, and if the outcome of the verification is positive;

5 - determining by means of "pole capacity" the number of radio channels and corresponding associated codes for the downlink radio path;

- verifying whether the codes provides can be hosted in the associated codes and if the number of associated

10 codes exceeds the codes provided for at least one service;

- negotiating at the Radio Resource Management (RRM) level at least one of the services provided in said network in such a way as to update the maximum

15 sustainable load (η_{MAX}).

8. Method as claimed in claim 7, characterised by the further steps of

- determining for each service a load factor per cell (η_{DL}) and corresponding values of power per channel for

20 the downlink radio path;

- verifying whether the power per channel of at least one service exceeds power limits prescribed for said service and, if the power per channel of at least one service exceeds the prescribed power limits;

25 - negotiating said service at the Radio Resource Management (RRM) level in such a way as to update the maximum sustainable load (η_{MAX}).

9. System for dimensioning a radio network based on Code Division Multiple Access or CDMA techniques, comprising a

30 computerised work station (50) programmed for implementing the method as claimed in any of the previous claims.

10. Computer product able to be loaded directly into the internal memory of a computerised work station (50) and comprising portions of software code to carry out, when the product is executed on the work station, the method
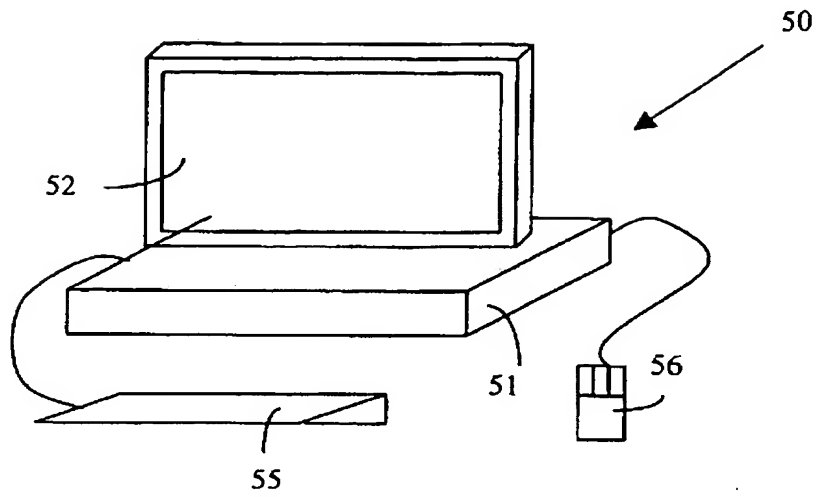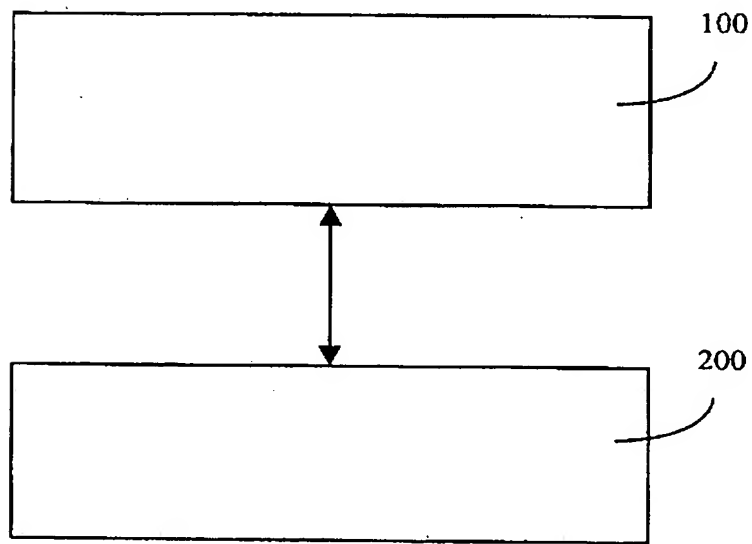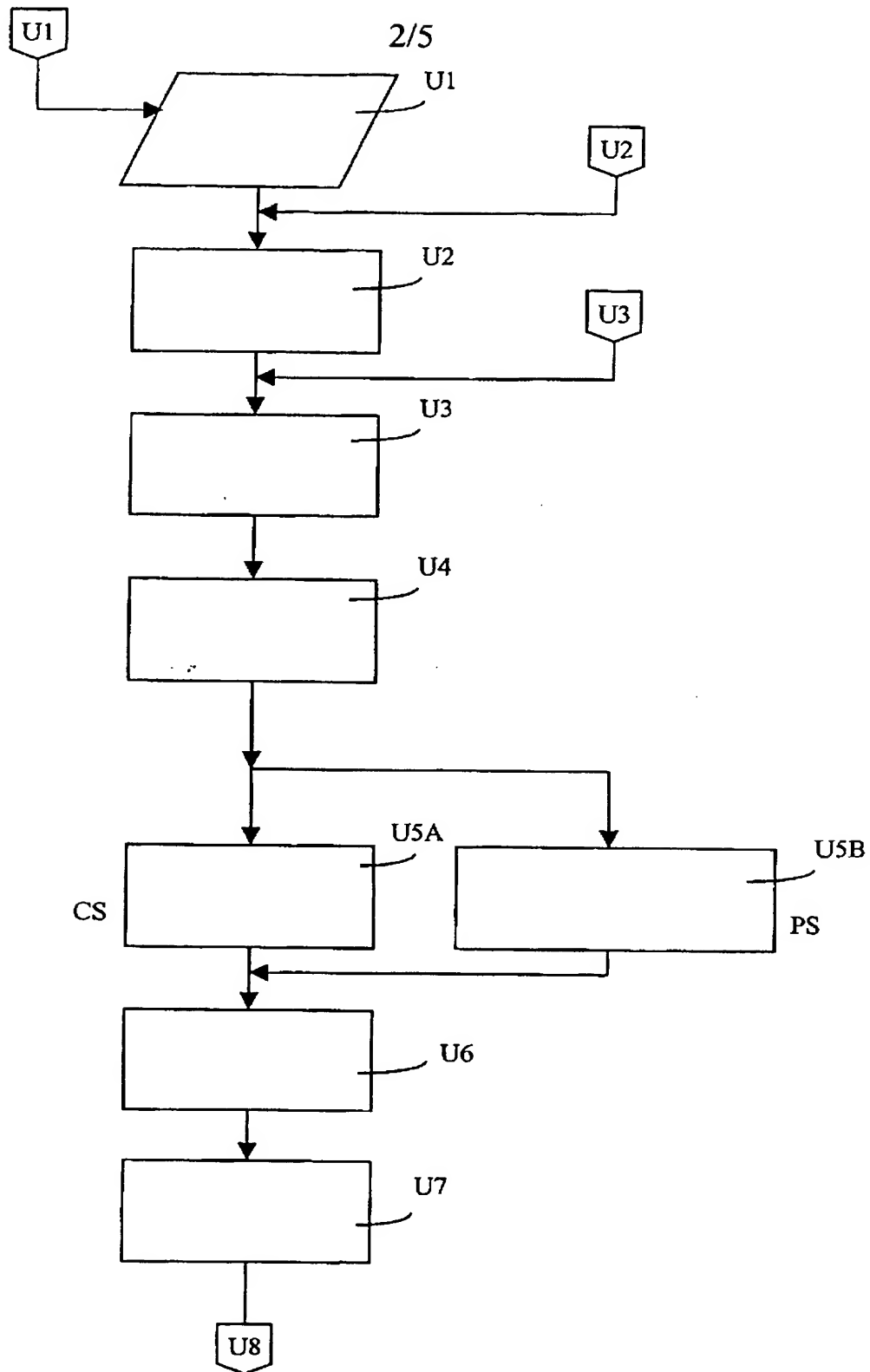5 as claimed in any of the claims from 1 through 8.

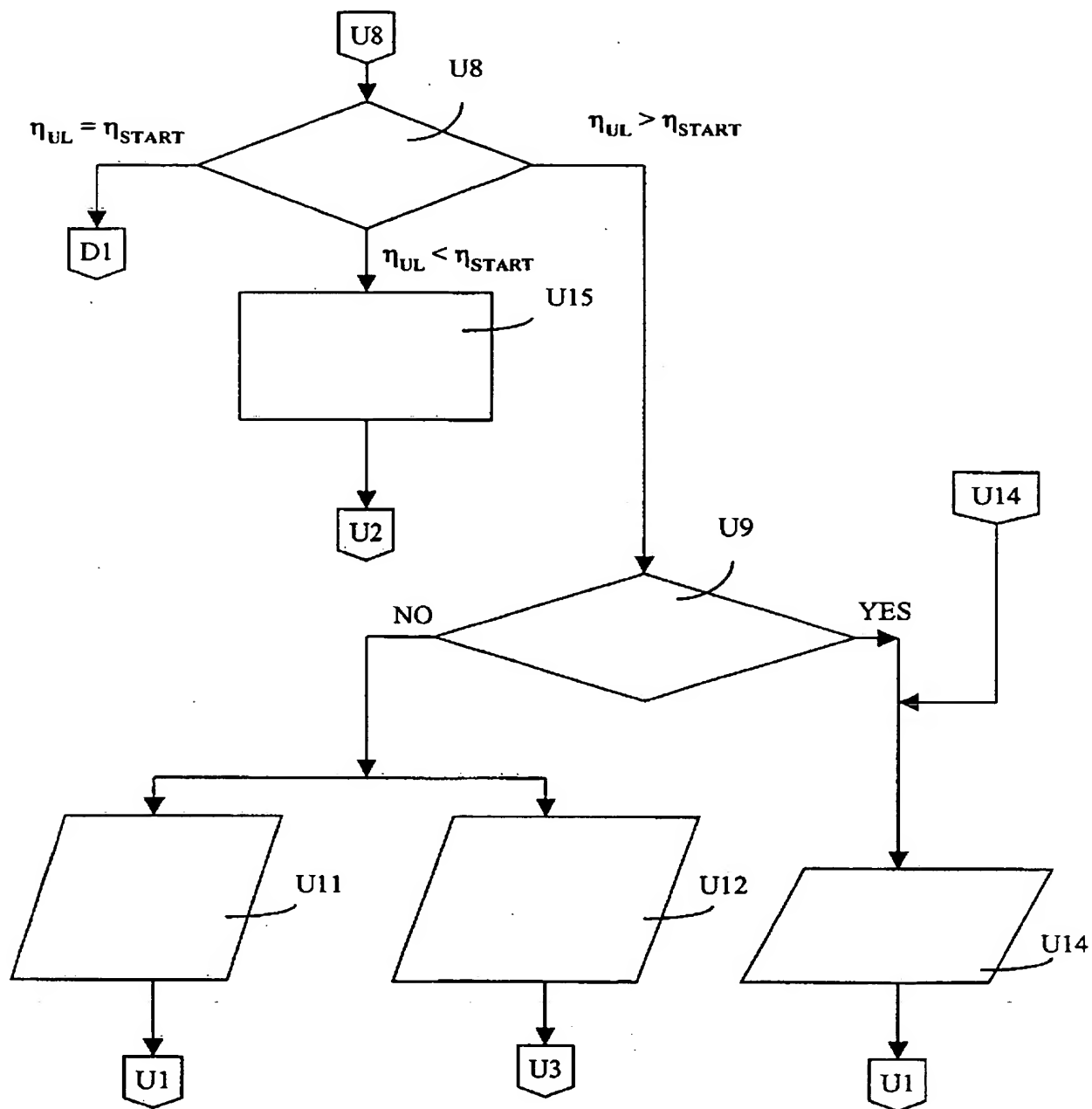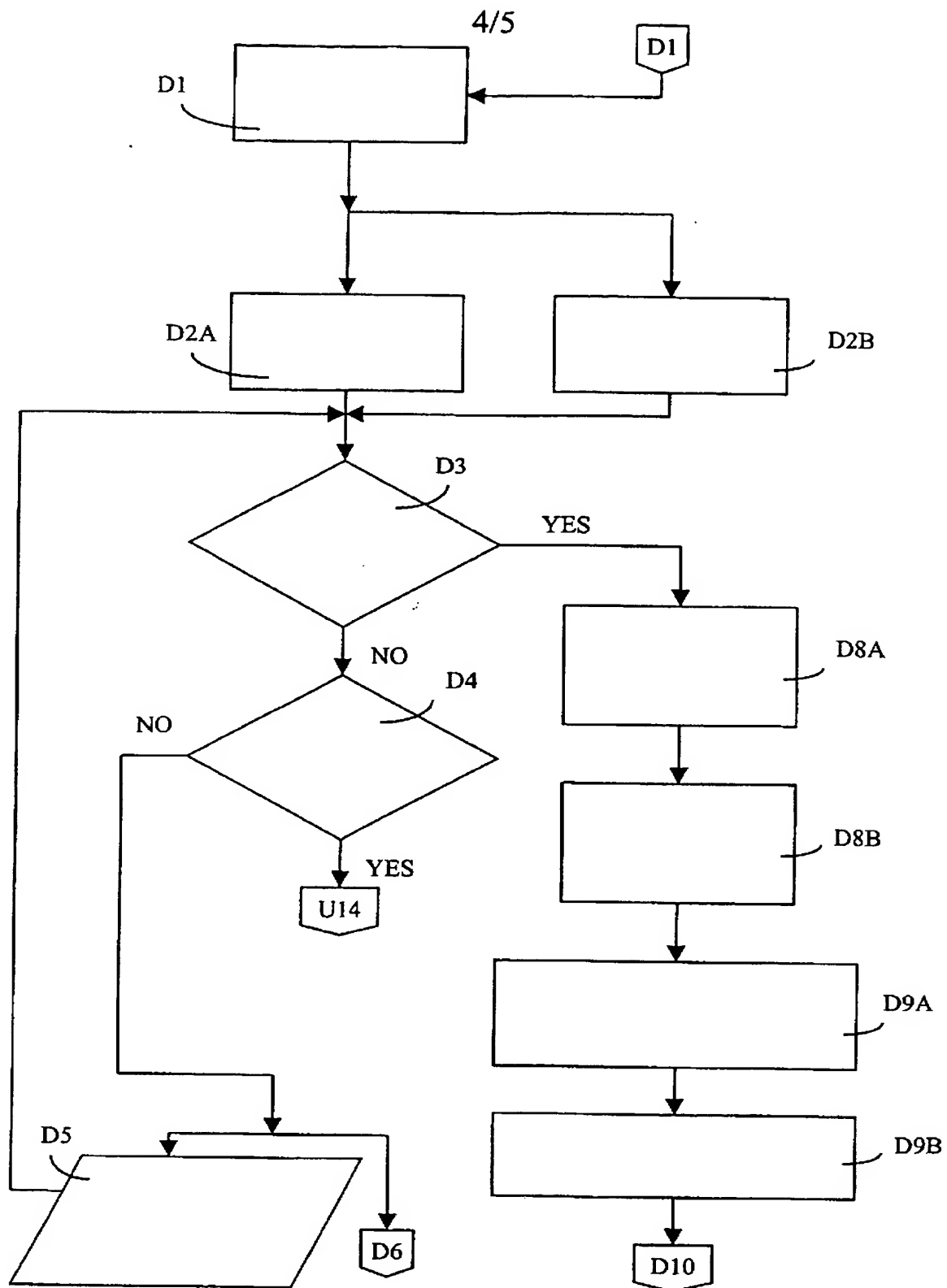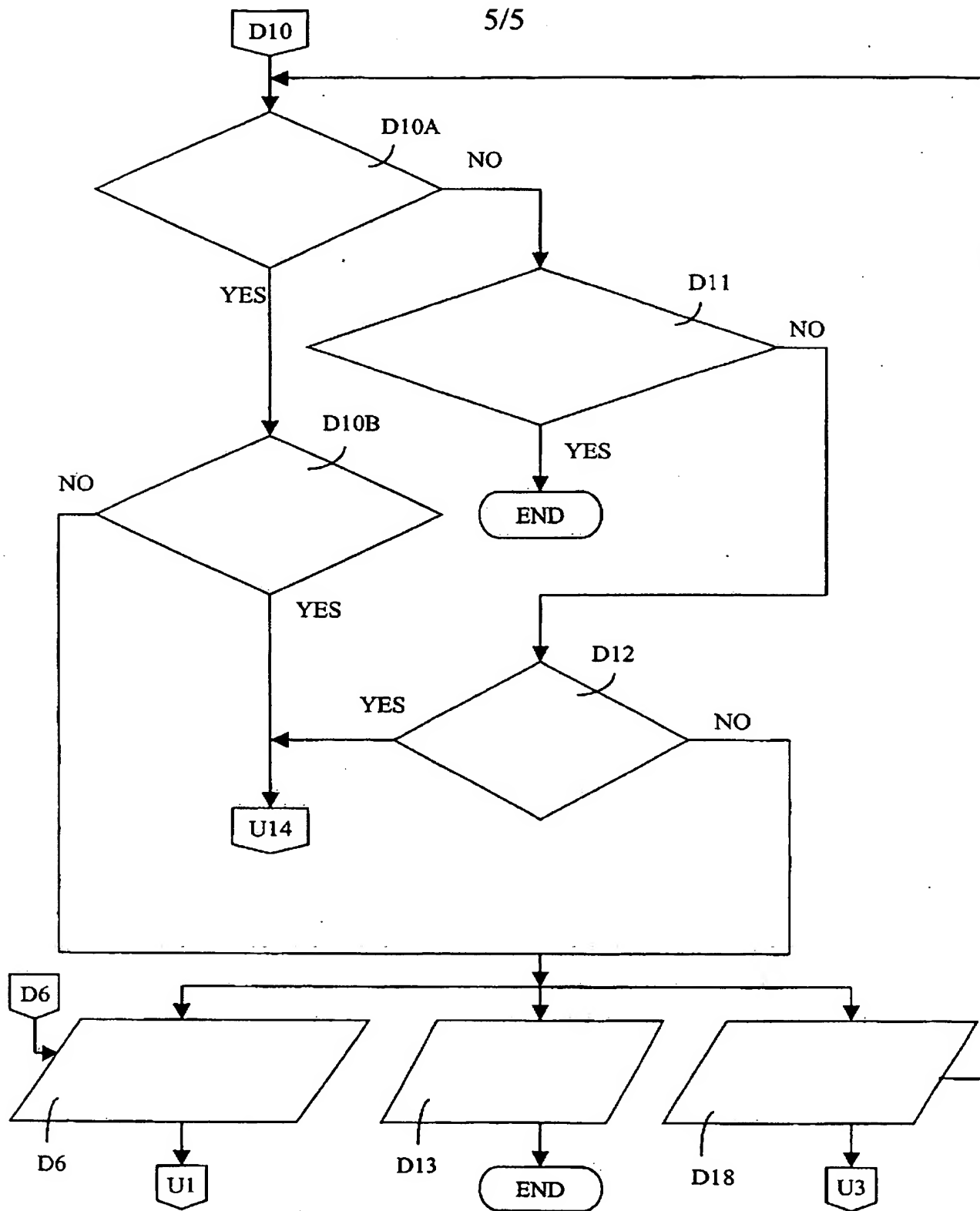Fig. 1

Fig. 2

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Fig. 3A

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Fig. 3B

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Fig. 3C

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Fig. 3D

A. CLASSIFICATION OF SUBJECT MATTER
IPC 7 H04Q7/36

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
IPC 7 H04Q

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

EPO-Internal

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category°	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	US 2002/102984 A1 (FURUSHAR ET AL.) 1 August 2002 (2002-08-01)	1,3-8
A	page 2, paragraph 17 - page 4, paragraph 39; figures	2
Y	WO 98/24199 A (NOKIA) 4 June 1998 (1998-06-04) page 4, line 16 - page 12, line 21; figures	1,3-8
A	WO 00/79821 A (QUALCOMM) 28 December 2000 (2000-12-28) page 3, line 8 - page 9, line 18; figures	1-10
A	WO 00/49824 A (NOKIA) 24 August 2000 (2000-08-24) page 5, line 20 - page 18, line 24; figures	1-10

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| X | Further documents are listed in the continuation of box C. | | X | Patent family members are listed in annex. |

° Special categories of cited documents :

"A" document defining the general state of the art which is not considered to be of particular relevance

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"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art.

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Date of the actual completion of the international search	Date of mailing of the international search report
22 December 2003	05/01/2004

Name and mailing address of the ISA	Authorized officer
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C.(Continuation) DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	BERNARDI DE R ET AL: "LOAD CONTROL STRATEGIES FOR MIXED SERVICES IN WCDMA" VTC 2000-SPRING. 2000 IEEE 51ST. VEHICULAR TECHNOLOGY CONFERENCE PROCEEDINGS. TOKYO, JAPAN, MAY 15-18, 2000, IEEE VEHICULAR TECHNOLGY CONFERENCE, NEW YORK, NY: IEEE, US, vol. 2 OF 3. CONF. 51, 15 May 2000 (2000-05-15), pages 825-829, XP000967985 ISBN: 0-7803-5719-1 page 825, paragraph II - page 828, paragraph VII; figures -----	1-10
P,X	WO 03/003775 A (ERICSSON) 9 January 2003 (2003-01-09) page 6, line 9 - page 62, line 2; figures -----	1-10

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